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(54) EXTRA-FINE COPPER ALLOY WIRE AND ITS PRODUCTION METHOD

(57)Abstract:
PROBLEM TO BE SOLVED: To provide extra-fine copper alloy wire having high tensile strength, excellent in bending resistance and also having high electric conductivity and to provide its production method.
SOLUTION: This extra-fine copper alloy wire is composed of a copper alloy having a wire diameter of 0.01 to 0.1 mm and having a composition containing, by mass, 0.05 to 0.9% Mg or In, and the balance copper with inevitable impurities, and also, its tensile strength is controlled to ≥343 MPa, elongation to ≥5%, and electric conductivity to ≥ 80% IACS by heat treating the wire after formation of its final diameter.

* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1]In a super-thin copper alloy wire which is 0.01-0.1 mm, a wire size does 0.05-0.9 mass % content of Mg or In, consists of a copper alloy which uses copper and an inevitable impurity as the remainder, and by and heat treatment after the last wire-size formation. A super-thin copper alloy wire having carried out 343 or more MPa and elongation, and making conductivity more than 80%IACS for tensile strength not less than 5%.
[Claim 2]In a manufacturing method of a super-thin copper alloy wire which is 0.01-0.1 mm, a wire size does 0.05-0.9 mass % content of Mg or In, A manufacturing method of a super-thin copper alloy wire wire drawing is performed to a copper alloy which uses copper and an inevitable impurity as the remainder, forming an extra fine wire, heat-treating continuously to an extra fine wire after the last wire-size formation, refining 343 or more MPa and elongation and refining conductivity for tensile strength not less than 5% more than 80%IACS.
[Claim 3]A manufacturing method of the super-thin copper alloy wire according to claim 2 which heat-treats continuously to the above-mentioned extra fine wire by induction heating by annealing by a tubular furnace, energization resistance heating by an energization heating apparatus, or an induction coil.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to a super-thin copper alloy wire and a manufacturing method for the same, and relates to a super-thin copper alloy wire especially used for the electric wire and cable conductor of electronic equipment, and a manufacturing method for the same.
[0002]
[Description of the Prior Art]In portable information and communication / record terminals, such as recent years, electronic equipment, for example, a notebook computer, a cellular phone, and a digital camcorder, Much more miniaturization, slimming down, and a weight saving are advanced, and the demand of super-thin-izing is increasing in the electric wire (cable) used for those electronic equipment. Since these cables are wired to a narrow space and severe bending and twist **** are received, the demand of flexibility is also increasing.
[0003]The thing in which the wire size generally twisted from several tens of strands (extra fine wire) which are about 0.02-0.1 mm as a super-thin cable conductor, or the thing which twisted this strand around the linear or band-like insulator with flexibility is mentioned.
[0004]As a good cable conductor of flexibility, the hard copper alloy wire (it is hereafter indicated as hard drawn copper wire) has been used from the former. About 686 MPa(s) (70 kgf/mm^2) order, its tensile strength is dramatically high and bends it, and this hard drawn copper wire is dramatically useful when distortion is small (distortion [For example, bending.]. 1% or less). However, from elongation being small, hard drawn copper wire was bent, and when distortion was large (distortion [For example, bending.]. more than 1%), it had the problem that sufficient crookedness life was not acquired. Hard drawn copper wire had fault of "rose ****" in a strand at the time of a terminal process.
[0005]So, by bending, when distortion is large, instead of hard drawn copper wire, the absorption power in which elongation is bent and distorted by fitness (before or after 20%) (plastic distortion) is high, and it has been examined that flexibility uses a good elastic copper alloy wire (it is hereafter indicated as annealed copper wire). However, when carrying out extrusion covering of the insulator and forming a cable in the conductor which consists of annealed copper wire, there was a problem that an open circuit arose in a conductor by insufficient strength.
[0006]Therefore, in order to cover a wide strain range (big distortion from a small distortion) and to improve the reliability of the flexibility of a cable conductor, the cable conductor excellent in tensile strength and elongation is required, and the super-thin copper alloy wire which consists of half-rigid material having the characteristic of hard drawn copper wire and annealed copper wire is called for.
[0007]However, under the present circumstances, the super-thin copper alloy wire with elongation comparable as annealed copper wire is not found out to the same extent [tensile strength] as hard drawn copper wire. For this reason, in the super-thin copper alloy wire which suppressed reduction in tensile strength to minimum, and raised elongation, needs are growing as a cable conductor for electronic equipment. As this super-thin copper alloy wire, a half-rigid Cu-Sn system alloyed wire is mentioned (refer to application for utility model registration No. 61703 [Showa 63 to]).
[0008]
[Problem(s) to be Solved by the Invention]However, for tensile strength to be high, and for flexibility to be good as a cable conductor for electronic equipment, and also to have the high conductivity near pure copper is desired. Sn which is an alloy composing element of a Cu-Sn system alloyed wire here, In [since the degree which contributes to the increase in the electrical specific resistance of pure copper is comparatively as large as 2.88 (10 $^{-8}$ omega-m / atomic %)] a Cu-Sn system alloy, even if a little content of Sn comes out and there is, conductivity falls substantially by content of Sn -- there was a problem to say (conductivity of Cu-0.30 mass %Sn before or after 80% IACS).
[0009]The purpose of this invention originated in consideration of the above situation is to provide a super-thin copper alloy wire with high conductivity, and a manufacturing method for the same for tensile strength to be high and good [flexibility].
[0010]
[Means for Solving the Problem]A super-thin copper alloy wire applied to this invention that the above-mentioned purpose should be attained, In a super-thin copper alloy wire which is 0.01-0.1 mm, a wire size does 0.05-0.9 mass % content of Mg or In, consists of a copper alloy which uses copper and an inevitable impurity as the remainder, and by and heat treatment after the last wire-size formation. Elongation is carried out and more than 343MPa (35

kgf/mm^2) makes conductivity more than 80%IACS for tensile strength not less than 5%.
[0011]According to the above composition, equivalent to a Cu-Sn system alloyed wire which is the conventional super-thin copper alloy wire, or a copper alloy wire which has the characteristic beyond it can be obtained by using Mg or In as an alloy composing element of a copper alloy.
[0012]On the other hand, a manufacturing method of a super-thin copper alloy wire concerning this invention, In a manufacturing method of a super-thin copper alloy wire which is 0.01-0.1 mm, a wire size does 0.05-0.9 mass % content of Mg or In, Wire drawing is performed to a copper alloy which uses copper and an inevitable impurity as the remainder, an extra fine wire is formed, and it heat-treats continuously to an extra fine wire after the last wire-size formation, and elongation is refined and more than 343MPa (35 kgf/mm^2) refines conductivity for tensile strength not less than 5% more than 80%IACS.
[0013]According to the above method, 0.05-0.9 mass % content Mg or In by heat-treating continuously to this wire rod, after forming in the last wire size a wire rod formed using a copper alloy which carries out and uses copper and an inevitable impurity as the remainder. It can be equivalent to a Cu-Sn system alloyed wire which is the conventional super-thin copper alloy wire, or the characteristic of a wire rod can be refined more than it.
[0014]It is preferred to heat-treat continuously to the above-mentioned extra fine wire by induction heating by annealing by a tubular furnace, energization resistance heating by an energization heating apparatus, or an induction coil.
[0015]A reason which limited a numerical value range as mentioned above is explained below.
[0016]A reason for having made a copper alloy into a Cu-Mg system or a Cu-In system is because conductivity is excellent as compared with a copper alloy of a Cu-Sn system mentioned above. Specifically, a conductive fall by having made Mg or In contain can be suppressed to one third at the time of making Sn contain.
[0017]Having made content of Mg or In into 0.05 - 0.9mass% here, When desired intensity cannot be obtained if content is less than [0.05mass%], and good flexibility is not obtained and content exceeds 0.9mass%, it is for conductivity to fall to less than 80%IACS.
[0018]A reason for having made tensile strength more than 343MPa (35 kgf/mm^2) prevents an open circuit at the time of wiring work (at the time [Or access]), and it is for obtaining good flexibility.
[0019]A reason for having made elongation into not less than 5% prevents "******" at the time of a terminal process of a stranded wire, and it is for making good flexibility at the time of receiving crookedness of a big distortion as compared with hard drawn copper wire whose elongation is about 1 to 3%.
[0020]It not only uses a reason for having made conductivity more than 80%IACS as a signal wire, but it is because it is usable also as a power source wire.
[0021]
[Embodiment of the Invention]Hereafter, the suitable 1 embodiment of this invention is described.
[0022]The super-thin copper alloy wire concerning this invention is an extra fine wire whose wire size is 0.01-0.1 mm, Consist Mg (or In) of 0.05 to 0.9 mass %, and a copper alloy which makes it desirable in 0.05-0.8 mass % content, and uses copper and an inevitable impurity as the remainder, and by and heat treatment after the last wire-size formation. Elongation is carried out and more than 80%IACS makes [more than 343MPa (35 kgf/mm^2)] conductivity more than 85%IACS for tensile strength preferably not less than 5%.
[0023]Next, the manufacturing method of the super-thin copper alloy wire concerning this invention is explained.
[0024]First, add Mg (or In) to the molten metal of oxygen free copper, and a copper alloy molten metal is formed in it, and 0.05 to Mg(or In) 0.9 mass % and the copper alloy rough drawing wire which makes it desirable in 0.05-0.8 mass % content, and uses copper and an inevitable impurity as the remainder are formed by continuous casting. Wire drawing (cold work) is performed to this rough drawing wire, and a wire size forms eventually the extra fine wire which is 0.01-0.1 mm.
[0025]Then, it heat-treats continuously to this extra fine wire by induction heating by annealing by a tubular furnace, the energization resistance heating by an energization heating apparatus, or an induction coil, Elongation is refined not less than 5%, more than 80%IACS refines [more than 343MPa (35 kgf/mm^2)] conductivity for tensile strength preferably more than 85%IACS, and a super-thin copper alloy wire is obtained.
[0026]Thus, the stranded wire which comes to twist two or more single tracks of a super-thin copper alloy wire or super-thin copper alloy wires which were obtained is used as a cable conductor. Various plating of Ag plating, Sn plating, nickel plating, etc. may be performed to the periphery of this super-thin copper alloy wire if needed, and the super-thin copper alloy wire by which plating covering was carried out may be used as a cable conductor.
[0027]Next, an operation of this invention is explained.
[0028]Although tensile strength has the intensity of more than 735MPa (75 kgf/mm^2) and the hard-drawn-copper-wire average, the wire rod of a wire drawing as (with no heat treatment), Since less than 1% and/or conductivity become [elongation] depending on the content of an alloy composing element in less than 80%IACS, it is necessary to heat-treat to a wire rod that the temper of the characteristic should be carried out (annealing process).
[0029]Under the present circumstances, when rewinding by a next process since wire rods stick if a wire size twists a wire rod of 0.1 mm or less around a bobbin and heat-treats to a batch type in an annealing furnace, it will disconnect or a crack will be attached on the surface of a wire rod. If a crack is attached to a wire surface, since it has an adverse effect on a crookedness life, i.e., flexibility, in the manufacturing method of the super-thin copper alloy wire material concerning this invention, it will have heat-treated continuously to the wire rod after wire drawing. By this, a possibility that a crack may be attached to the surface of the wire rod after heat treatment

disappears, and the flexibility of a wire rod becomes still better by extension.
[0030]In the manufacturing method of the super-thin copper alloy wire material concerning this invention, By adjusting suitably various kinds of heat treatment conditions (for example, induced current values, such as line velocity, the degree of furnace temperature, a pressure value of an energization heating apparatus, and an induction coil) in continuous heat treatment, the temper of each characteristic of a super-thin copper alloy wire can be performed.
[0031]Sn which is an alloy composing element of the conventional Cu-Sn system alloyed wire mentioned above had the degree comparatively as large as 2.88 (10^{-8} omega-m / atomic %) which contributes to the increase in the electrical specific resistance of pure copper. On the other hand, the super-thin copper alloy wire concerning this invention is making Mg or In contain as an alloy composing element, and Mg or In has respectively a degree dramatically as small as 0.65 and 1.06 (10^{-8} omega-m / atomic %) which contributes to the increase in the electrical specific resistance of pure copper. As a result, since the decline in the conductivity by Mg or In in a Cu-Mg system or a Cu-In system alloyed wire serves as the abbreviation 1/3 in the case of Sn in a Cu-Sn system alloyed wire, it can obtain the copper alloy wire excellent in conductivity.
[0032]Although mainly used as a signal wire, since the super-thin copper alloy wire concerning this invention has conductivity comparable as pure copper depending on the content or the heat treatment condition of an alloy composing element (Mg or In), it becomes available also as a power source wire.
[0033]
[Example](Examples 1-5) Using a small continuous casting machine, add Mg to the molten metal of oxygen free copper of 99.9999% of purity, and a copper alloy molten metal is formed in it, and Mg is contained in the range of 0.07 - 0.9 mass %, and five kinds of phi8mm copper alloy rough drawing wires which use copper and an inevitable impurity as the remainder are formed. The chemical composition of each copper alloy rough drawing wire is Cu-0.07mass%Mg, Cu-0.15mass%Mg, Cu-0.30mass%Mg, Cu-0.70mass%Mg, and Cu-0.90mass%Mg, respectively.
[0034]Next, cold drawing processing is performed to each of these rough drawing wires, and a phi0.08mm extra fine wire is formed.
[0035]Then, in 500 m/min and voltage, line velocity heat-treats each of these extra fine wires continuously by through and energization resistance heating to the energization heating apparatus adjusted to 34V, and five kinds of super-thin copper alloy wires are obtained.
[0036](Examples 6-10) Using a small continuous casting machine, add In to the molten metal of oxygen free copper of 99.9999% of purity, and a copper alloy molten metal is formed in it, and In is contained in the range of 0.07 - 0.9 mass %, and five kinds of phi8mm copper alloy rough drawing wires which use copper and an inevitable impurity as the remainder are formed. The chemical composition of each copper alloy rough drawing wire is Cu-0.07mass%In, Cu-0.15mass%In, Cu-0.30mass%In, Cu-0.70mass%In, and Cu-0.90mass%In, respectively.
[0037]Next, cold drawing processing is performed to each of these rough drawing wires, and a phi0.08mm extra fine wire is formed.
[0038]Then, in 500 m/min and voltage, line velocity heat-treats each of these extra fine wires continuously by through and energization resistance heating to the energization heating apparatus adjusted to 34V, and five kinds of super-thin copper alloy wires are obtained.
[0039](Comparative example 1) Except that chemical composition uses the copper alloy rough drawing wire of Cu-0.01mass%Mg, a super-thin copper alloy wire is obtained like Examples 1-5.
[0040](Comparative example 2) Except that chemical composition uses the copper alloy rough drawing wire of Cu-1.20mass%Mg, a super-thin copper alloy wire is obtained like Examples 1-5.
[0041](Comparative example 3) Cold drawing processing is performed to the same copper alloy rough drawing wire (Cu-0.01mass%Mg) of chemical composition as Example 3, and a phi0.08mm extra fine wire is formed in it. It did not heat-treat to this extra fine wire.
[0042](Comparative example 4) Except that chemical composition uses the copper alloy rough drawing wire of Cu-0.01mass%In, a super-thin copper alloy wire is obtained like Examples 6-10.
[0043](Comparative example 5) Except that chemical composition uses the copper alloy rough drawing wire of Cu-1.20mass%In, a super-thin copper alloy wire is obtained like Examples 6-10.
[0044](Comparative example 6) Cold drawing processing is performed to the same copper alloy rough drawing wire (Cu-0.01mass%In) of chemical composition as Example 8, and a phi0.08mm extra fine wire is formed in it. It did not heat-treat to this extra fine wire.
[0045](Comparative example 7) Using a small continuous casting machine, add Sn to the molten metal of oxygen free copper of 99.9999% of purity, and a copper alloy molten metal is formed in it, and Sn is contained in the range of 0.30 mass %, and the phi8mm copper alloy rough drawing wire which uses copper and an inevitable impurity as the remainder is formed.
[0046]Next, cold drawing processing is performed to this rough drawing wire, and a phi0.08mm extra fine wire is formed.
[0047]Then, in 500 m/min and voltage, line velocity heat-treats this extra fine wire continuously by through and energization resistance heating to the energization heating apparatus adjusted to 34V, and a super-thin copper alloy wire is obtained.
[0048]The chemical composition and the various characteristics (tensile strength (MPa), extended (%), conductivity (%IACS), and flexibility) of each super-thin copper alloy wire of Examples 1-10 and the comparative examples 1-7 are shown in Table 1.

[0049]Here, flexibility evaluated by the crookedness life in a bend test. The bend test pinched the super-thin copper alloy wire with a bending jig 1 mm in radius, and hung 30-g weight and measured the number of times of bending until it repeats and fractures by performing 90-degree crookedness right and left. Flexibility made x what has **, and less than 30 times and difficulty in some which have difficulty a little with O and 30 to 50 times in what has as good a crookedness life as 50 times or more.
[0050]
[Table 1]

		銅合金化学組成 (mass%)	引張強さ (MPa)	引張強さ (kgf/mm^2)	伸び (%)	導電率 (%IACS)	屈曲性 *1
実施例	1	Cu−0.07Mg	355	36.2	8.3	97.8	○
	2	Cu−0.15Mg	353	36.0	7.5	96.9	○
	3	Cu−0.30Mg	364	37.1	7.9	93.0	○
	4	Cu−0.70Mg	378	38.5	7.8	87.0	○
	5	Cu−0.90Mg	402	41.0	5.5	80.1	○
	6	Cu−0.07In	348	35.5	8.6	98.0	○
	7	Cu−0.15In	356	36.3	7.9	97.1	○
	8	Cu−0.30In	367	37.4	7.5	93.2	○
	9	Cu−0.70In	380	38.8	7.0	88.0	○
	10	Cu−0.90In	392	40.0	6.0	80.3	○
比較例	1	Cu−0.01Mg	295	30.1	11.3	98.5	△
	2	Cu−1.20Mg	404	41.2	5.5	75.8	○
	3	Cu−0.30Mg (熱処理なし)	807	82.3	2.1	87.8	×
	4	Cu−0.01In	295	30.1	11.3	98.8	△
	5	Cu−1.20In	404	41.2	5.5	75.8	○
	6	Cu−0.30In (熱処理なし)	787	80.3	2.3	88.2	×
	7	Cu−0.30Sn	374	38.1	8.7	80.1	○

＊1　○：良、△：やや難、×：難

[0051]As shown in Table 1, as for the super-thin copper alloy wire of the comparative example 7 which is the conventional Cu-Sn system alloyed wire, tensile strength was [374MPa (38.1 kgf/mm^2) and elongation of conductivity] 80.1%IACS(s) 8.7%. Flexibility was good. On the other hand, 348 - 402MPa (35.5 to 41.0 kgf/mm^2) and elongation was [the conductivity of each super-thin copper alloy wire of Examples 1-10 of tensile strength] 80.1 to 98.0%IACS(s) 5.5 to 8.6%. All of flexibility were good.
[0052]From this, each super-thin copper alloy wire of Examples 1-10 can check having the characteristic equivalent to the conventional Cu-Sn system copper alloy wire. Here, if Examples 3 and 8 and the comparative example 7 with same content of an alloy composing element are compared, the conductivity of the super-thin copper alloy wire of Examples 3 and 8 is high rather than the super-thin copper alloy wire of the comparative example 7. Therefore, each super-thin copper alloy wire of Examples 1-10 can check equivalent to the conventional Cu-Sn system copper alloy wire or having the characteristic beyond it.
[0053]On the other hand, as for each super-thin copper alloy wire of the comparative examples 1 and 4, in elongation, conductivity all indicated the highest values in an example to be IACS and 98.8%IACS 98.5% 11.3%, respectively. However, the content of Mg and In which are alloy composing elements was 0.01 mass %, respectively, since it was less than a stipulated range (0.05 to 0.9 mass %), tensile strength is low with 295MPa (30.1 kgf/mm^2), respectively, and, as a result, flexibility had difficulty a little.
[0054]The tensile strength of 404MPa (41.2 kgf/mm^2) and elongation was as good as 5.5% respectively, and the flexibility of each super-thin copper alloy wire of the comparative examples 2 and 5 was also good. However, the content of Mg and In which are alloy composing elements is 1.20 mass %, respectively, and since it is more than a stipulated range (0.05 to 0.9 mass %), conductivity is low with IACS 75.8%, respectively.
[0055]Each super-thin copper alloy wire of the comparative examples 3 and 6 showed the value of 807MPa (82.3 kgf/mm^2), 787MPa (80.3 kgf/mm^2), and the highest in an example, and conductivity was as good as 87.8%IACS and 88.2%IACS. [tensile strength] However, since heat treatment after wire drawing had not been performed, elongation

is low with 2.1% and 2.3%, respectively, and, as a result, flexibility had difficulty.
[0056]As mentioned above, it cannot be overemphasized that an embodiment of the invention is not limited to the embodiment mentioned above, and various things are otherwise assumed.
[0057]
[Effect of the Invention]By heat-treating continuously to this wire rod, after, forming in the last wire size above the wire rod formed using the Cu-Mg system or the Cu-In system alloy in short according to this invention. The outstanding effect that it can be equivalent to the Cu-Sn system alloyed wire which is the conventional super-thin copper alloy wire, or the characteristic of a wire rod can be refined more than it is demonstrated.

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(54)【発明の名称】 極細銅合金線及びその製造方法

(57)【要約】
【課題】 引張強さが高く、耐屈曲性が良好で、かつ、導電率の高い極細銅合金線及びその製造方法を提供するものである。
【解決手段】 本発明に係る極細銅合金線は、線径が０．０１～０．１ｍｍで、Ｍｇ又はＩｎを０．０５～０．９質量％含有し、銅及び不可避不純物を残部とする銅合金からなり、かつ、最終線径形成後の熱処理により、引張強さを３４３ＭＰａ以上、伸びを５％以上、導電率を８０％ＩＡＣＳ以上としたものである。